Universitat de Barcelona

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

11th MedCOF / 2018

Role of sea-ice and snow cover on predictability of the Northern Hemisphere cold season

Javier García-Serrano (UB, BSC)

MEDSCOPE
MEDiterranean Services Chain based On climate PrEdictions

Universitat de Barcelona

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

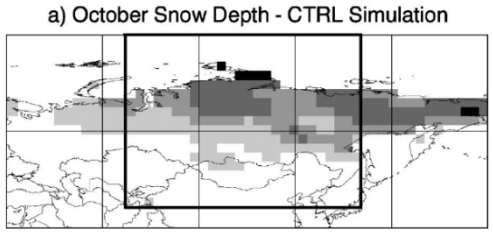
EXCELENCIA SEVERO OCHOA

Eurasian snow cover in autumn (**OCT**)

[Cohen and co-authors]

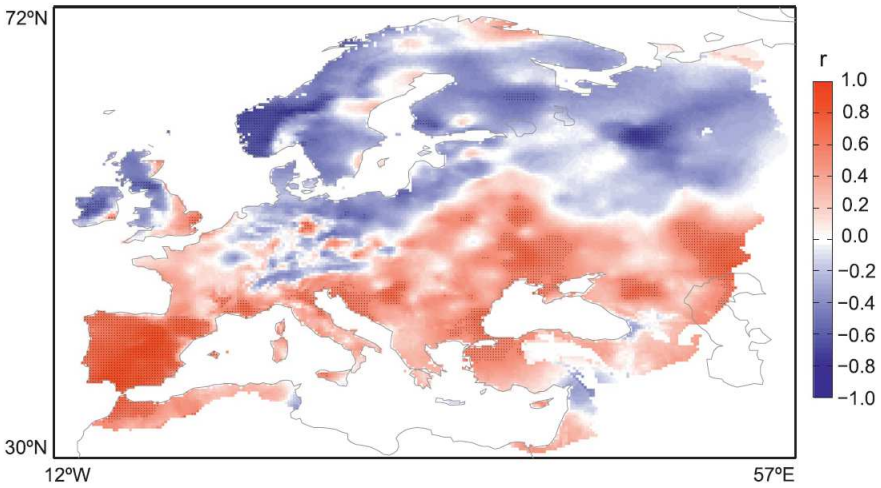
snow advance index - SAI / r(AO)=0.6-0.8

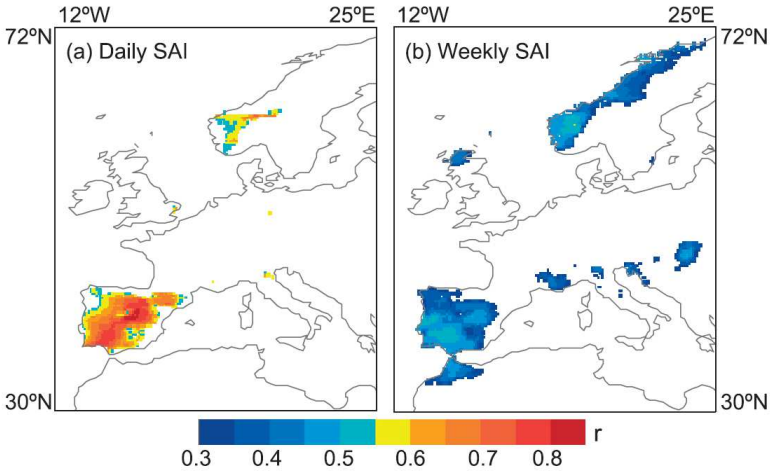
[Cohen and Jones 2011]



[Gong et al. 2003]

WINTER





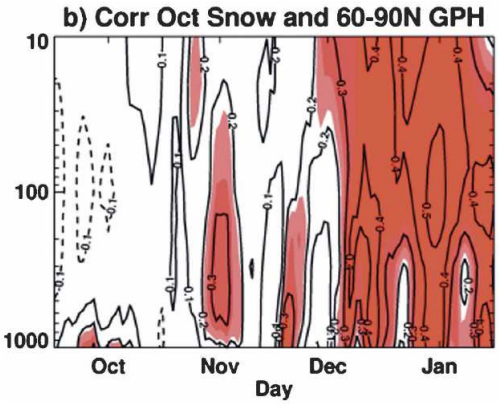
correlation / empirical prediction skill

[Brands et al. 2012]

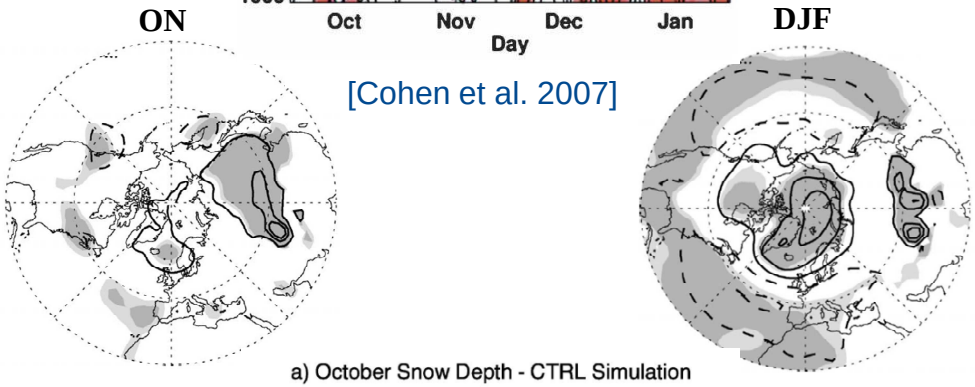
MEDSCOPE
MeDiterranean Services Chain based On climate PrEdictions

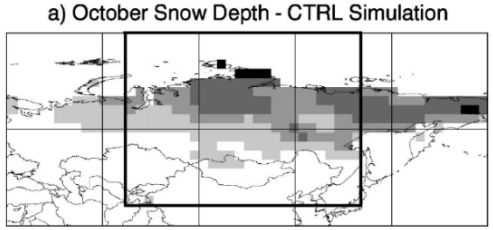
Eurasian snow cover in autumn (**OCT**)
[Cohen and co-authors]

snow advance index - SAI / r(AO)=0.6-0.8
[Cohen and Jones 2011]



[Cohen et al. 2007]

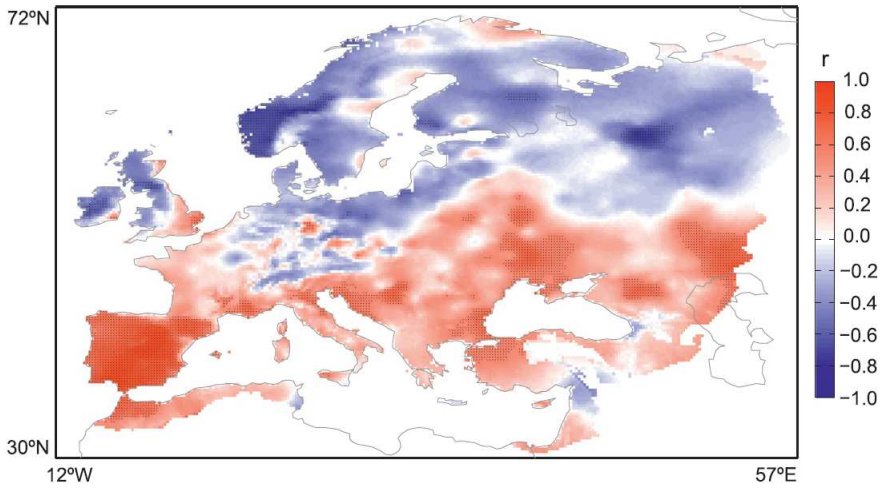


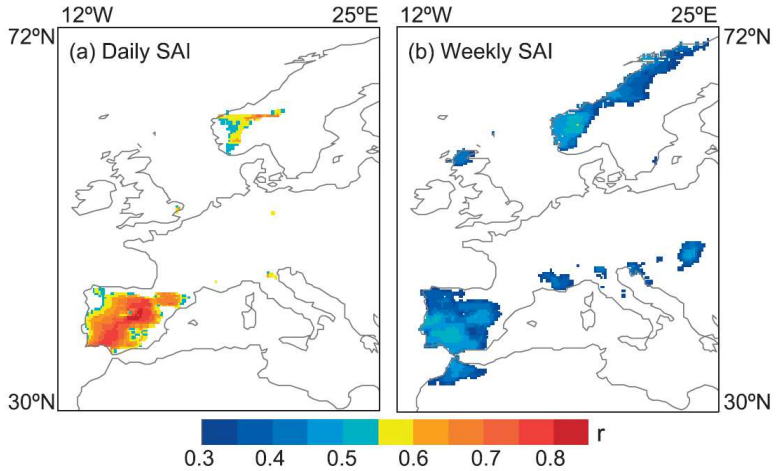


[Gong et al. 2003]

MEDSCOPE
MeDiterranean Services Chain based On climate PrEdictions

WINTER





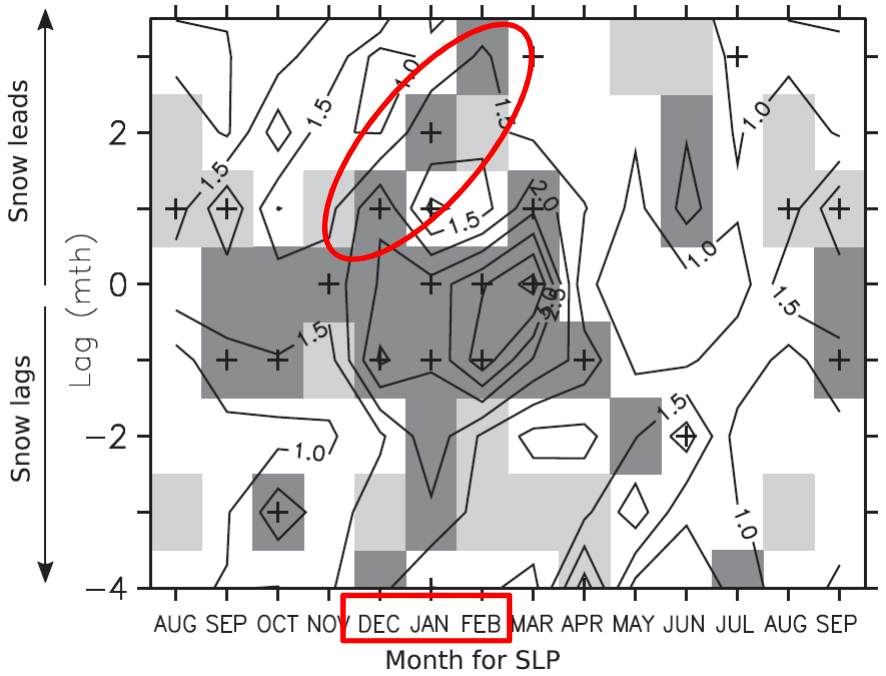
correlation / empirical prediction skill
[Brands et al. 2012]

Eurasian snow cover in autumn (**OCT**)

↓ ?

Eurasian snow cover in autumn (**NOV**)

WINTER



[Gastineau et al. 2017]

Local and remote impacts of seasonal snow cover on atmospheric circulation have been explored extensively, with observational and modelling efforts focusing on how Eurasian autumn snow-cover variability potentially drives Northern Hemisphere atmospheric circulation via the generation of deep, planetary-scale atmospheric waves. Despite climate modelling advances, models remain challenged to reproduce the proposed sequence of processes by which snow cover can influence the atmosphere, calling into question the robustness of this coupling.

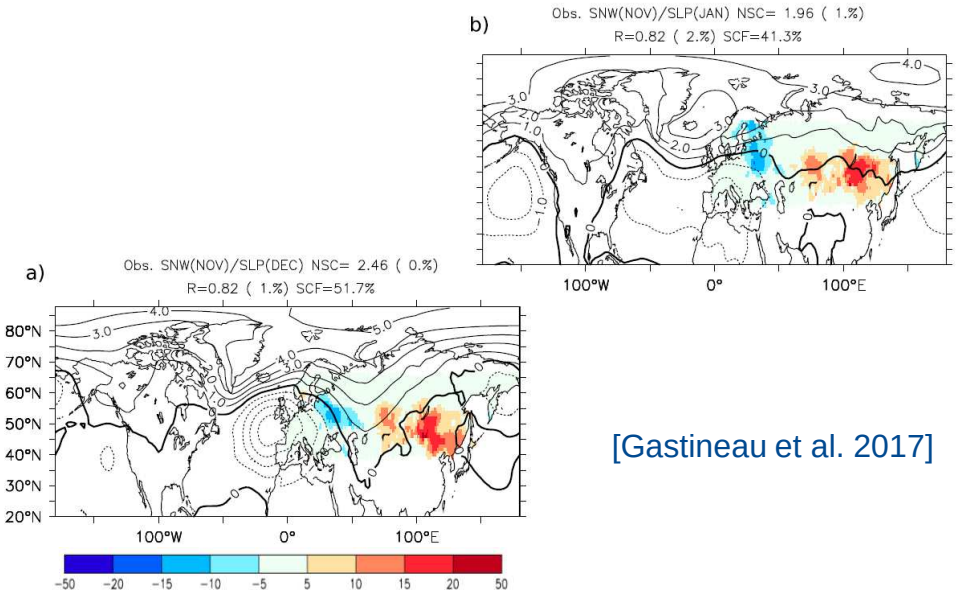
Review in *Nature Climate Change*
[Henderson et al. 2018]

Eurasian snow cover in autumn (**OCT**)

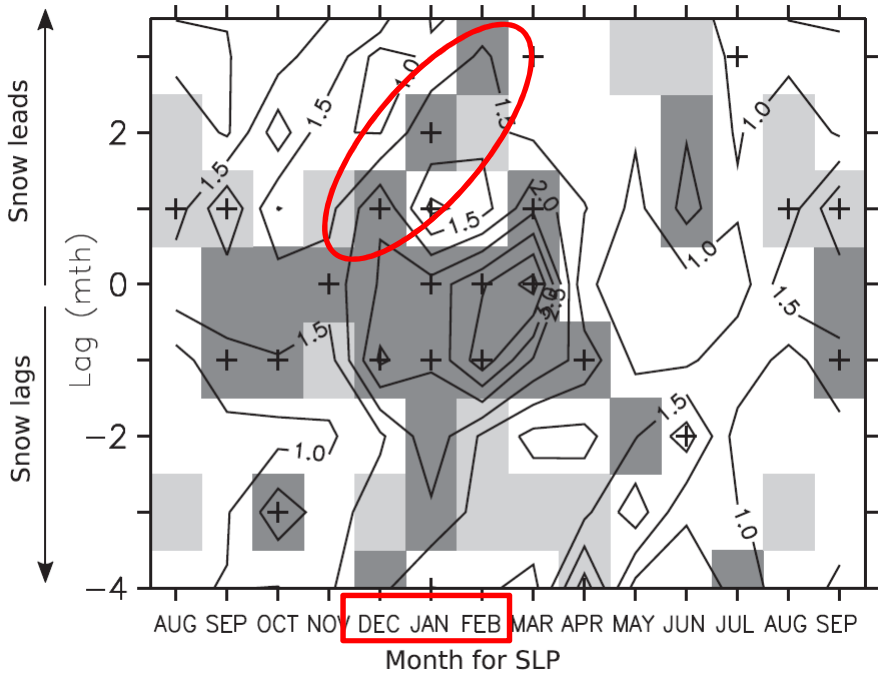
↓ ?

Eurasian snow cover in autumn (**NOV**)

WINTER



[Gastineau et al. 2017]



Local and remote impacts of seasonal snow cover on atmospheric circulation have been explored extensively, with observational and modelling efforts focusing on how Eurasian autumn snow-cover variability potentially drives Northern Hemisphere atmospheric circulation via the generation of deep, planetary-scale atmospheric waves. Despite climate modelling advances, models remain challenged to reproduce the proposed sequence of processes by which snow cover can influence the atmosphere, calling into question the robustness of this coupling.

Review in *Nature Climate Change*
[Henderson et al. 2018]

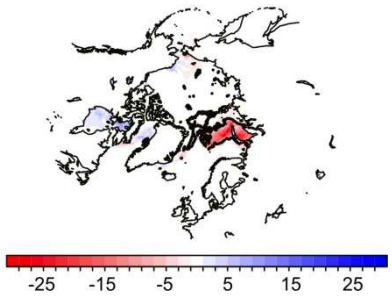
MEDSCOPE
MeDiterranean Services Chain based On climate PrEdictions

Barents-Kara sea-ice concentration in autumn (**NOV**)

[García-Serrano et al. 2015; King et al. 2015; Koenigk et al. 2015]

[Scaife et al. 2014; Dunstone et al. 2016]

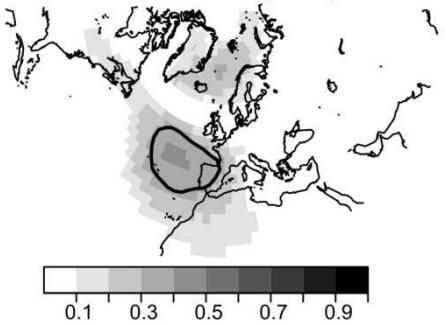
a) **MCA-SIC/BK**$_{Nov}$ x SIC (**nov**)



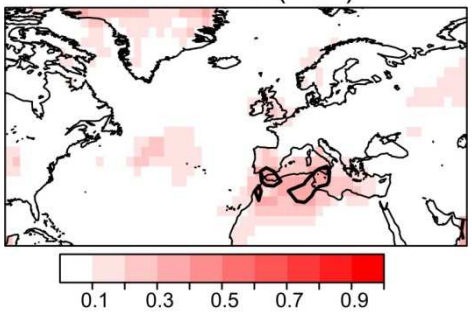
[García-Serrano et al. 2015, 2016]

WINTER

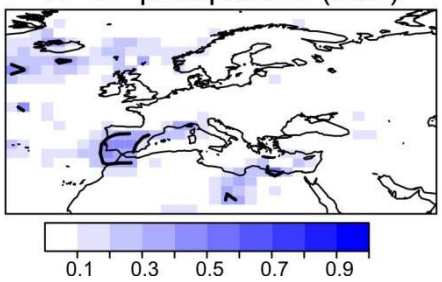
ERA-int SLP (DJF)



ERA-int SAT (DJF)



GPCP precipitation (DJF)

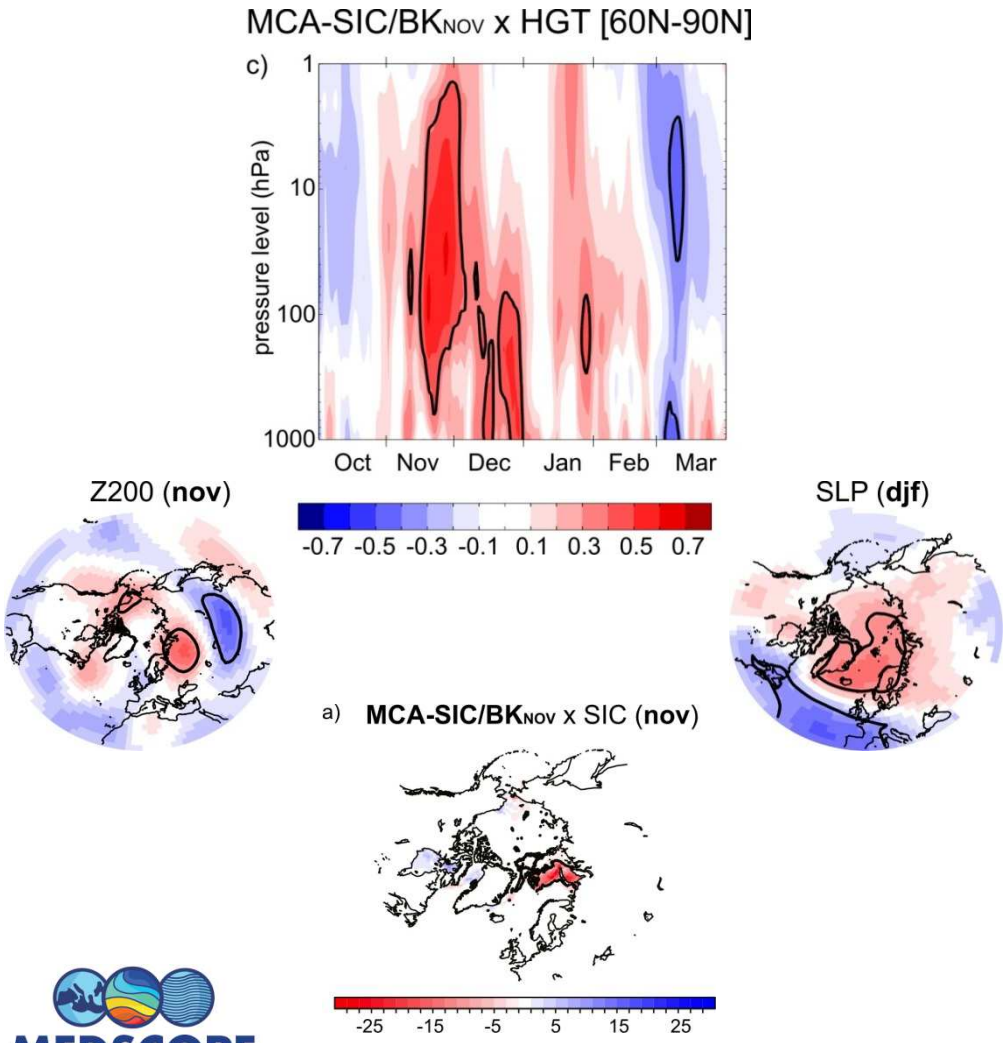


empirical prediction skill

[García-Serrano et al. 2015]

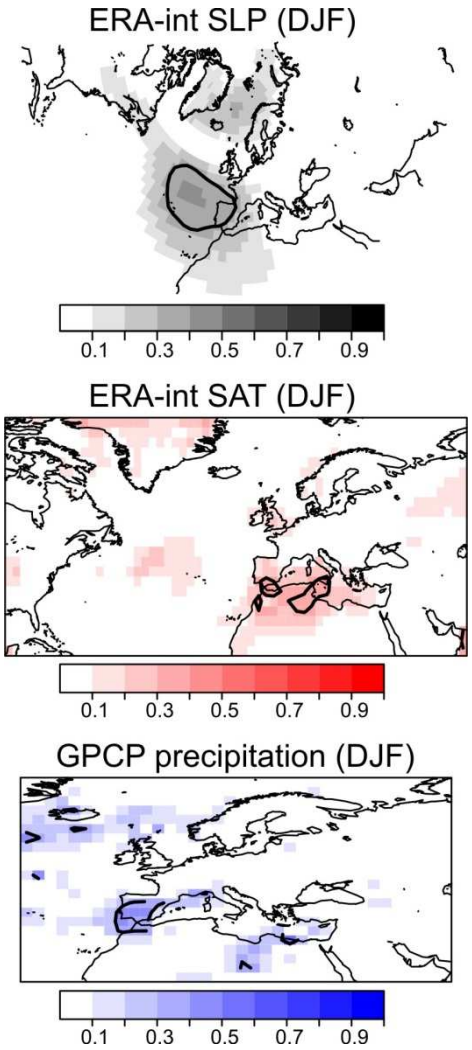
Barents-Kara sea-ice concentration in autumn (**NOV**)

[García-Serrano et al. 2015; King et al. 2015; Koenigk et al. 2015]
[Scaife et al. 2014; Dunstone et al. 2016]



[García-Serrano et al. 2015, 2016]

WINTER

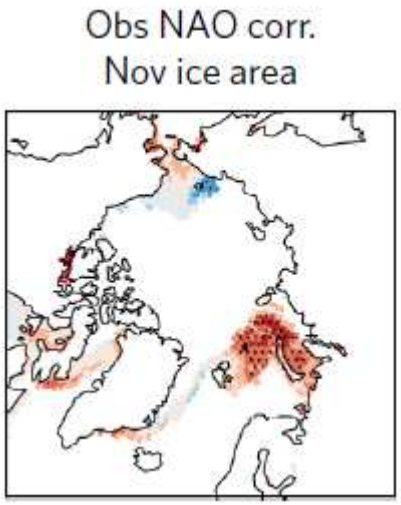


empirical prediction skill
[García-Serrano et al. 2015]

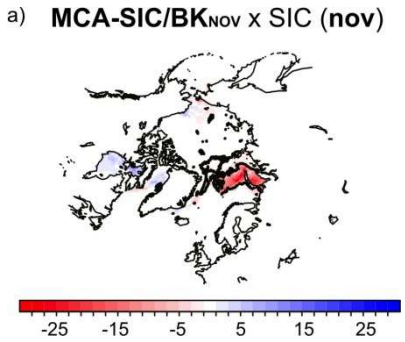
Barents-Kara sea-ice concentration in autumn (**NOV**)

[García-Serrano et al. 2015; King et al. 2015; Koenigk et al. 2015]

[Scaife et al. 2014; Dunstone et al. 2016]

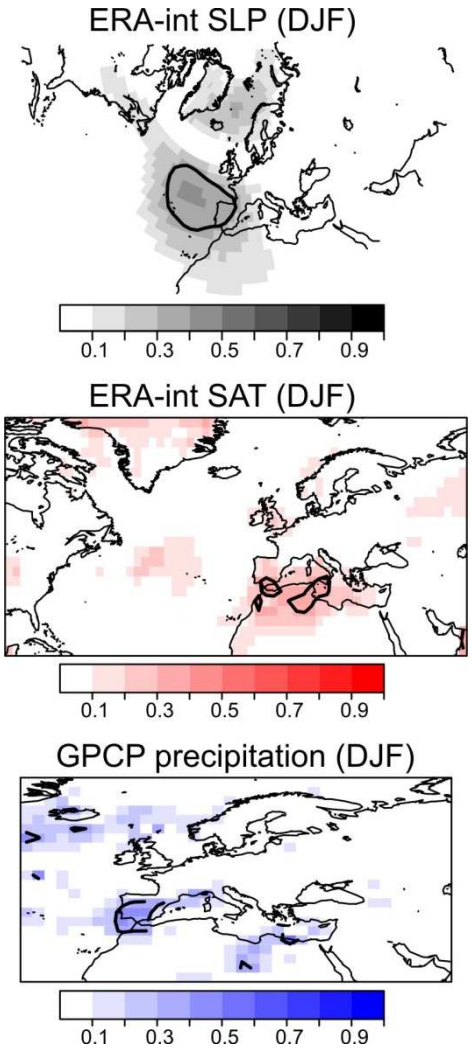


[Dunstone et al. 2016]



[García-Serrano et al. 2015, 2016]

WINTER

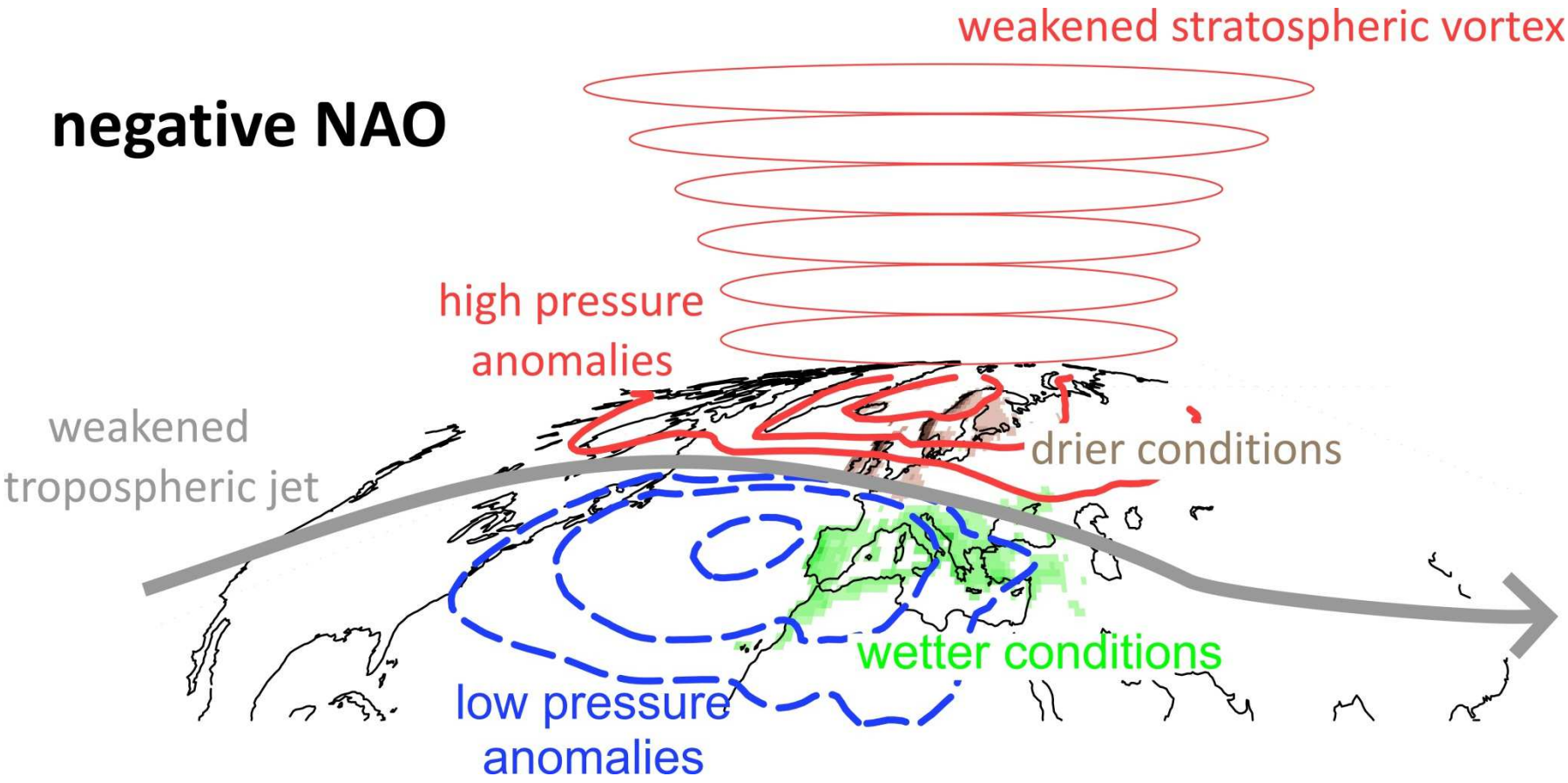


empirical prediction skill

[García-Serrano et al. 2015]

stratospheric pathway to winter NAO

(sea-ice reduction / increased snow)



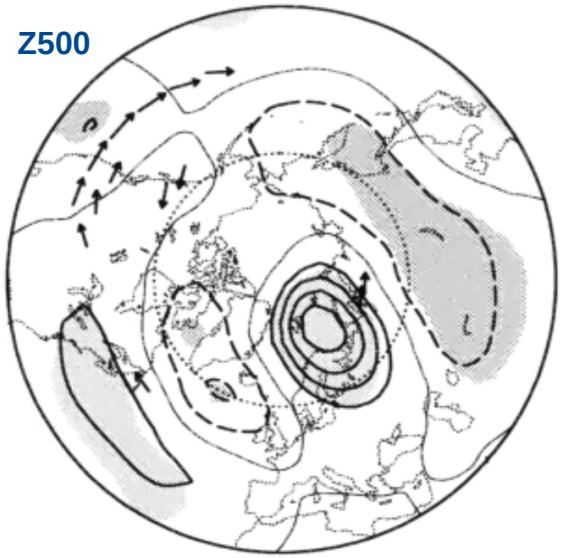
MEDSCOPE
MeDiterranean Services Chain based On climate PrEdictions

what precedes to the winter NAO → NAO precursors

November

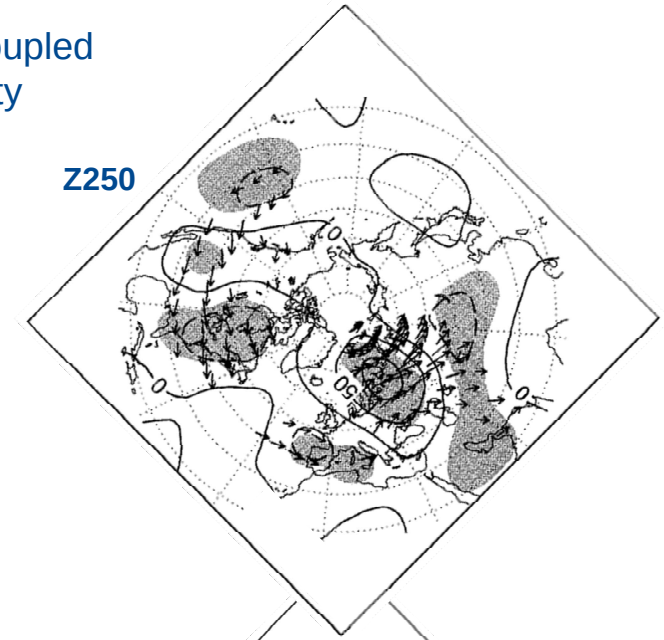
wave-like anomalies over Eurasia coupled
to troposphere-stratosphere variability

Z500

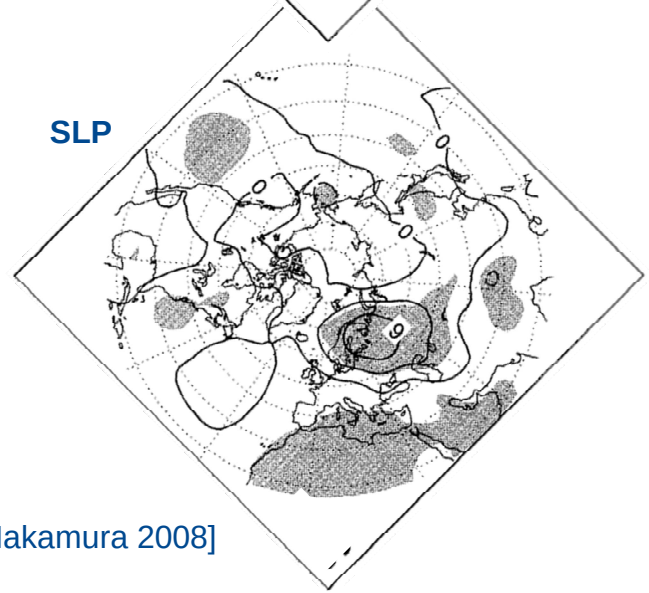


[Kuroda and Kodera 1999]

Z250

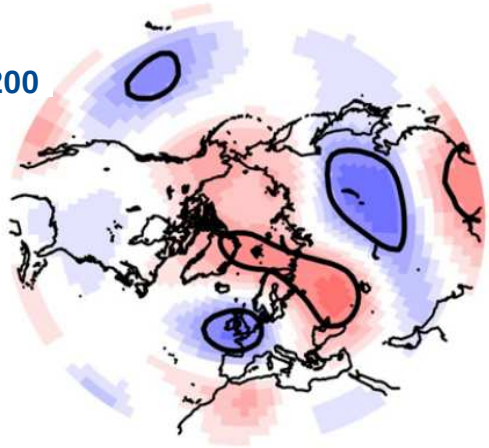


SLP

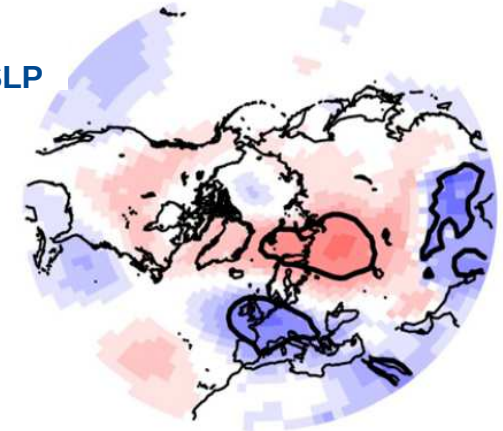


[Takaya and Nakamura 2008]

Z200



SLP



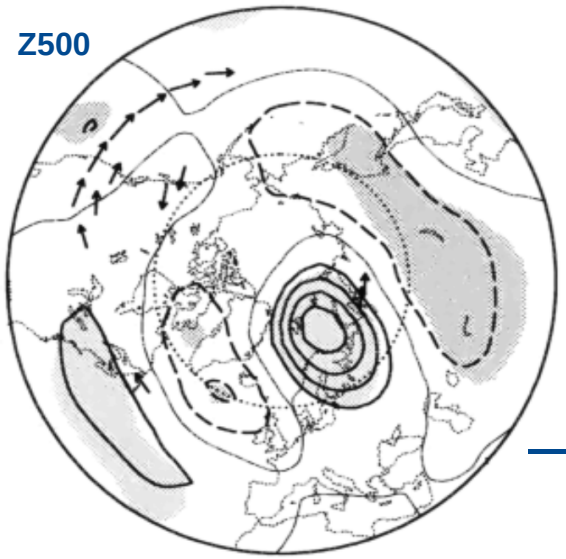
[García-Serrano et al. 2015]

what precedes to the winter NAO → NAO precursors

November

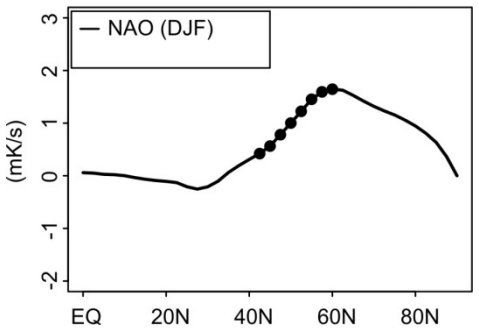
wave-like anomalies over Eurasia coupled
to troposphere-stratosphere variability

Z500

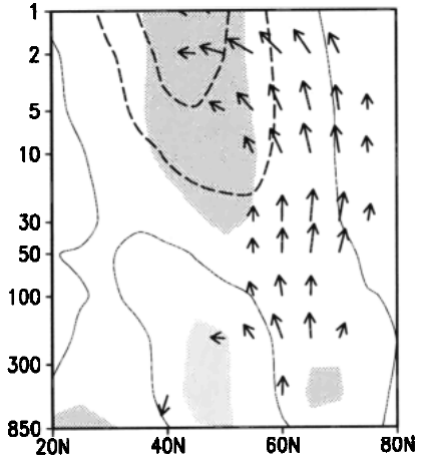


[Kuroda and Kodera 1999]

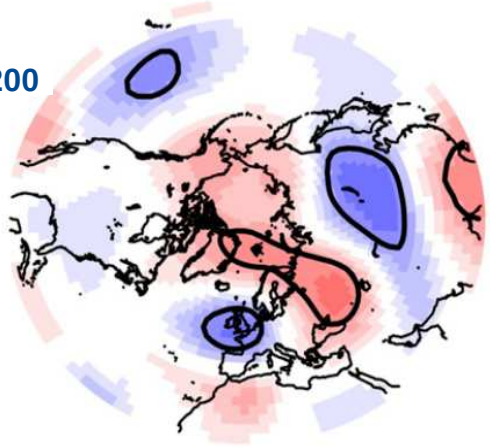
[v*T*] at 100hPa (**nov**)

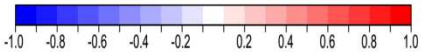


E-P flux

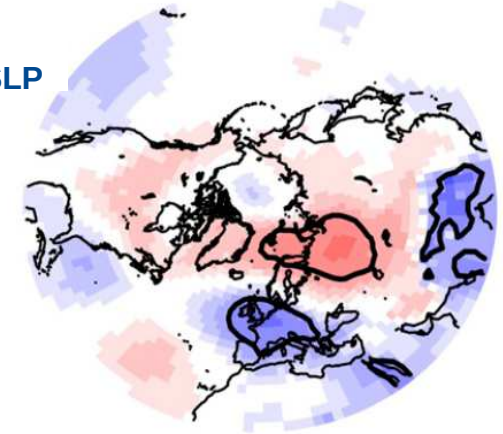


Z200





SLP



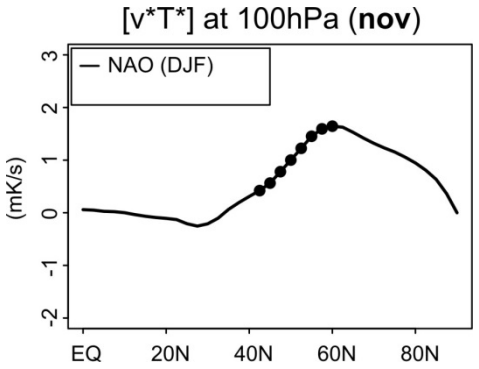
[García-Serrano et al. 2015]

MEDSCOPE
MeDiterranean Services Chain based On climate PrEdictions

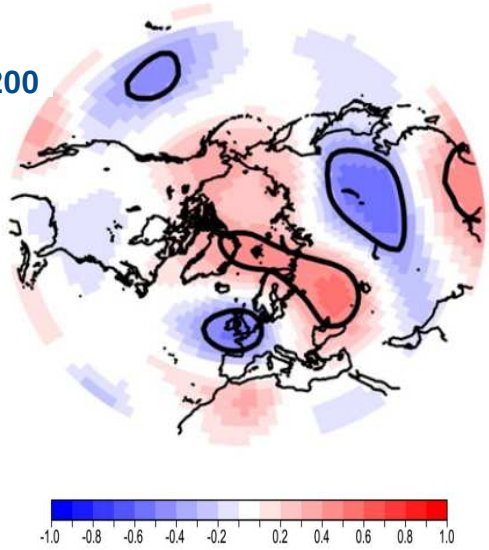
what precedes to the winter NAO → NAO precursors

November

wave-like anomalies over Eurasia coupled
to troposphere-stratosphere variability

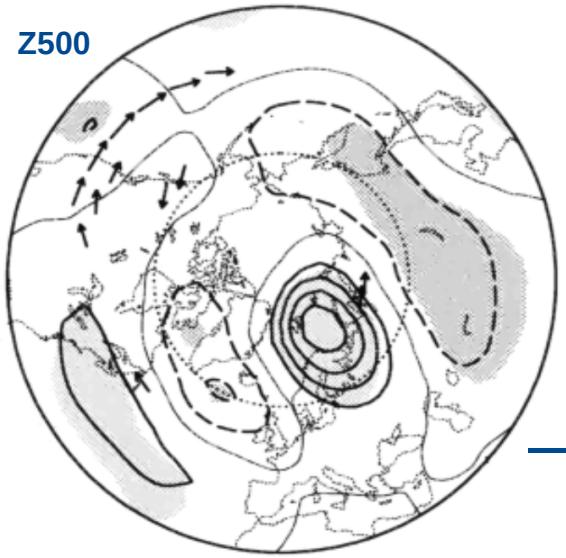


Z200

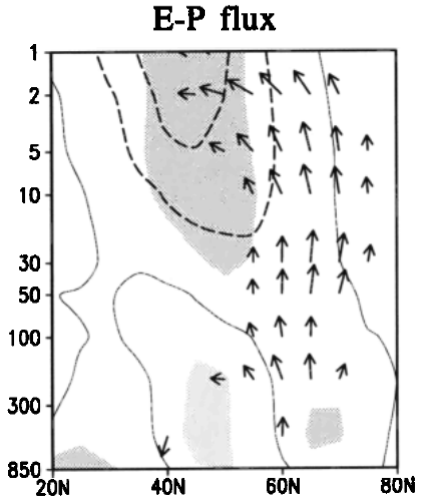


[García-Serrano et al. 2015]

Z500



[Kuroda and Kodera 1999]



linear interference with
climatological wave pattern

[Garfinkel et al. 2010]

MEDSCOPE
MeDiterranean Services Chain based On climate PrEdictions

NAO precursors linked to surface forcing ?

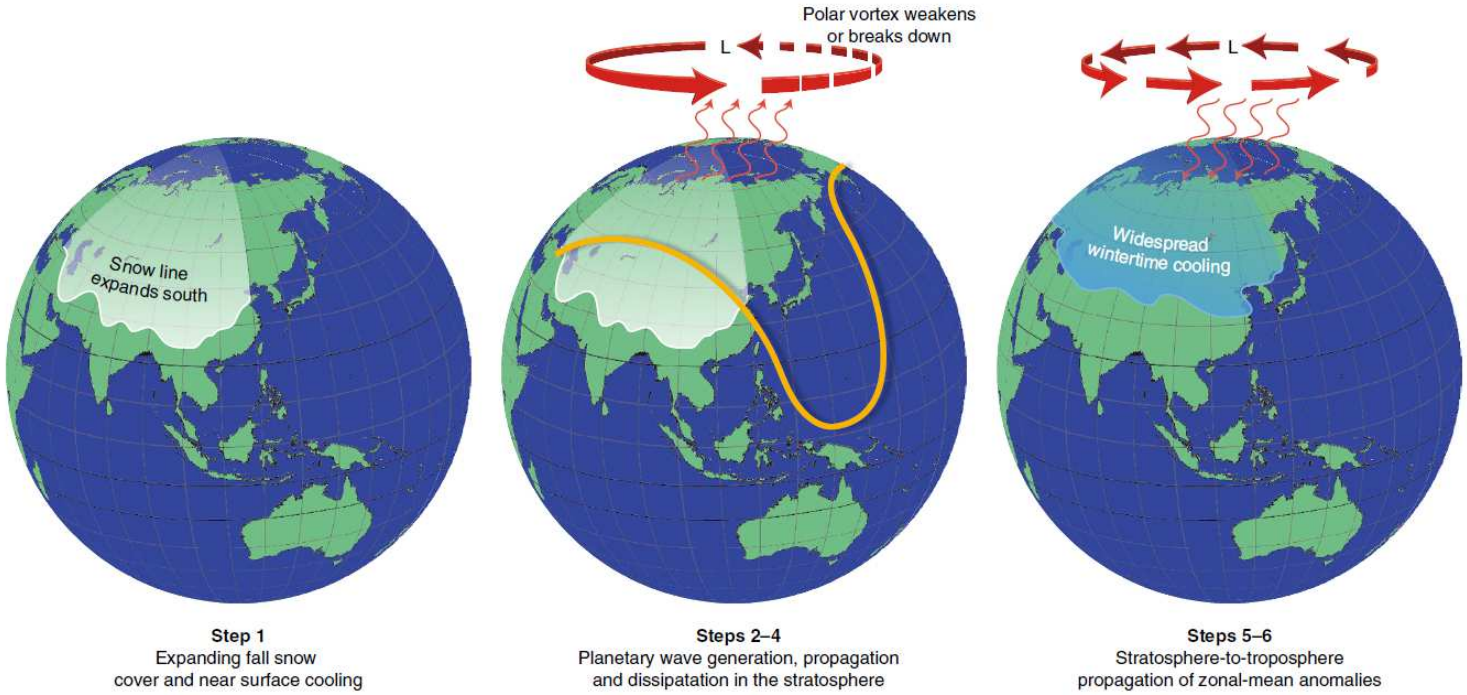
sea-ice reduction → heats and moistens the boundary layer (*turbulent fluxes*)

increased snow → cools the boundary layer (*radiative fluxes*)

NAO precursors linked to surface forcing ?

sea-ice reduction → heats and moistens the boundary layer (*turbulent fluxes*)

increased snow → cools the boundary layer (*radiative fluxes*)



Review in *Nature Climate Change*
[Henderson et al. 2018]

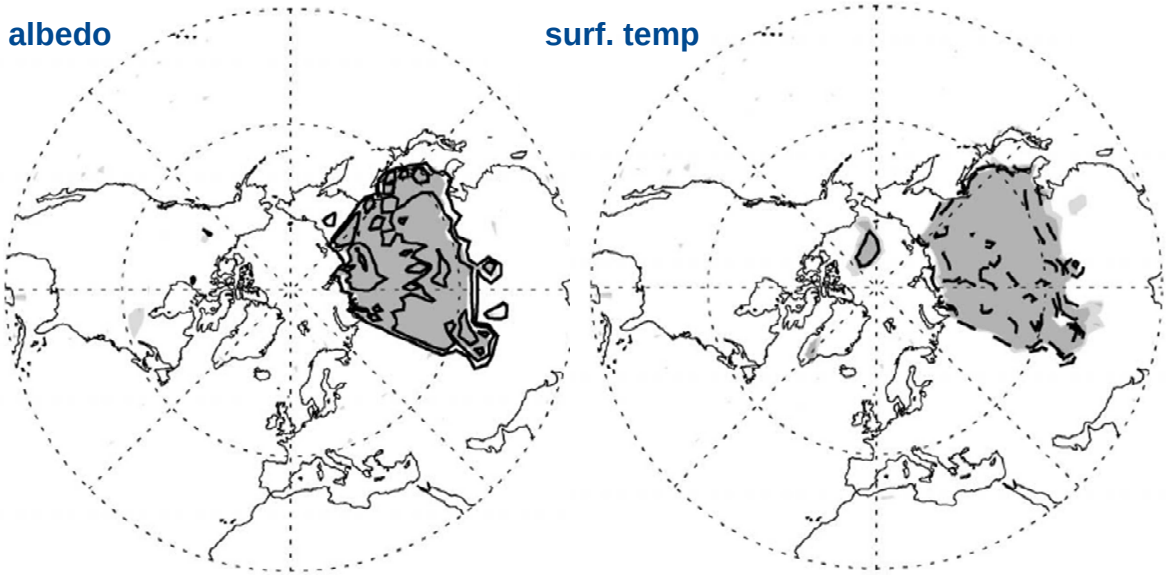
NAO precursors linked to surface forcing ?

sea-ice reduction → heats and moistens the boundary layer (*turbulent fluxes*)

increased snow → cools the boundary layer (*radiative fluxes*)

Step 1
Expanding fall snow
cover and near surface cooling

[Henderson et al. 2018]



[Gong et al. 2003]

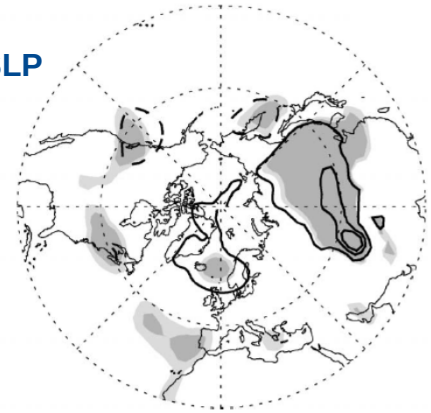
NAO precursors linked to surface forcing ?

sea-ice reduction → heats and moistens the boundary layer (*turbulent fluxes*)

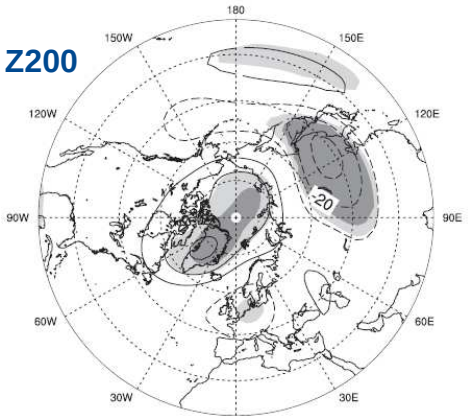
increased snow → cools the boundary layer (*radiative fluxes*)

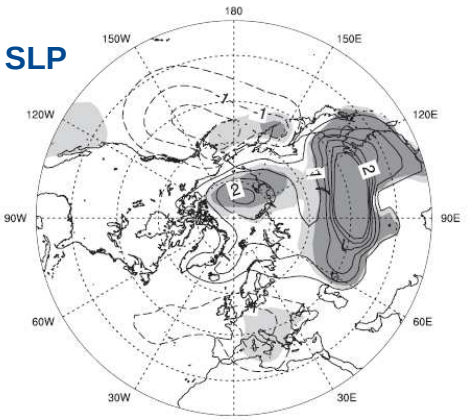
Step 1
Expanding fall snow
cover and near surface cooling

[Henderson et al. 2018]



[Gong et al. 2003]





[Peings et al. 2012]

NAO precursors linked to surface forcing ?

sea-ice reduction → heats and moistens the boundary layer (*turbulent fluxes*)

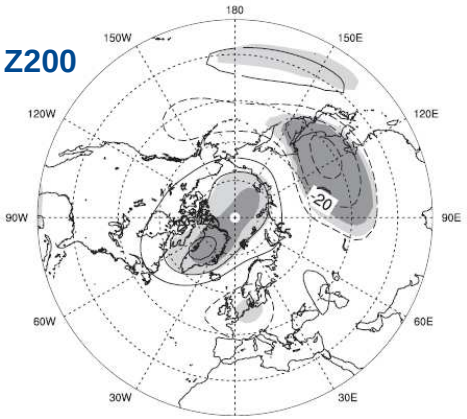
increased snow → cools the boundary layer (*radiative fluxes*)

Step 1
Expanding fall snow
cover and near surface cooling

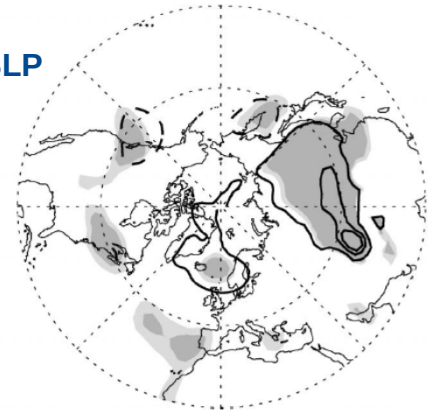
[Henderson et al. 2018]

climatological wave pattern

Z200

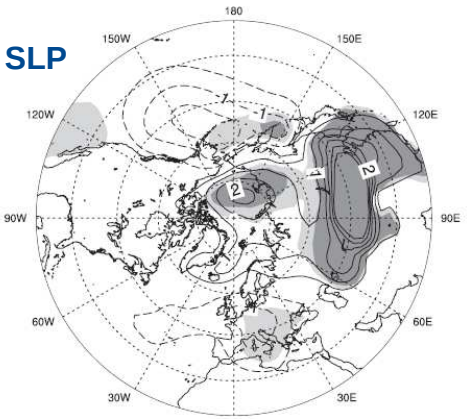


SLP



[Gong et al. 2003]

SLP



[Peings et al. 2012]

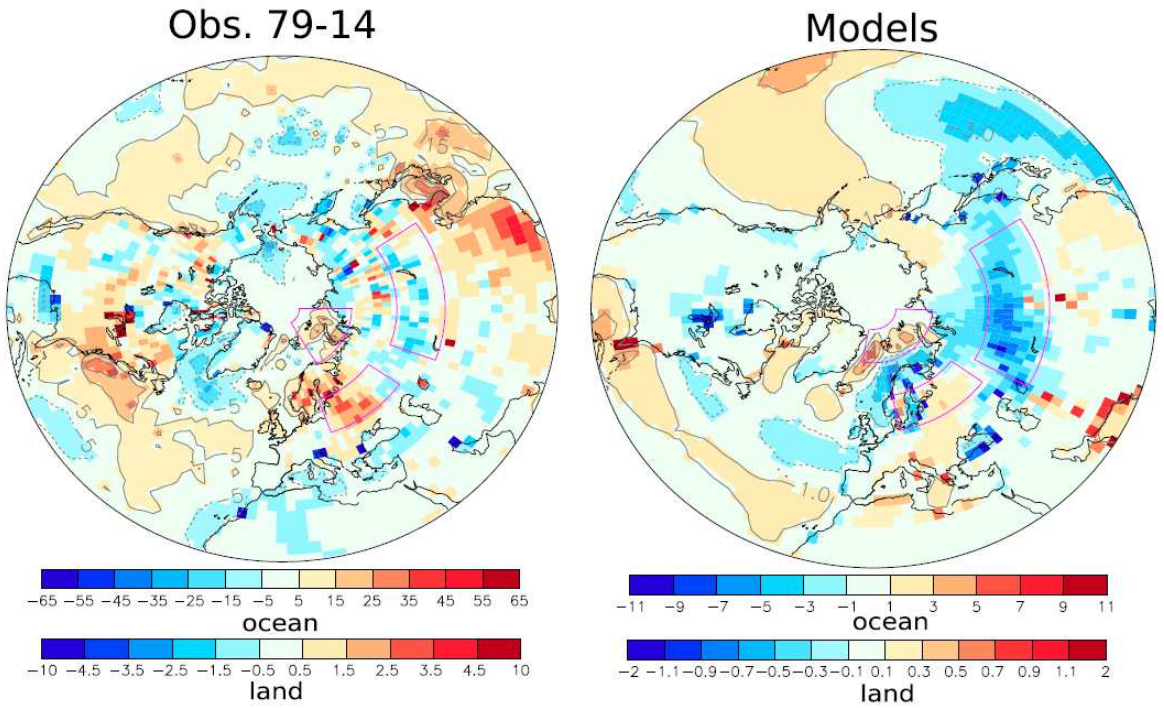
NAO precursors linked to surface forcing ?

sea-ice reduction → heats and moistens the boundary layer (*turbulent fluxes*)

increased snow → cools the boundary layer (*radiative fluxes*)

Step 1
Expanding fall snow
cover and near surface cooling

[Henderson et al. 2018]

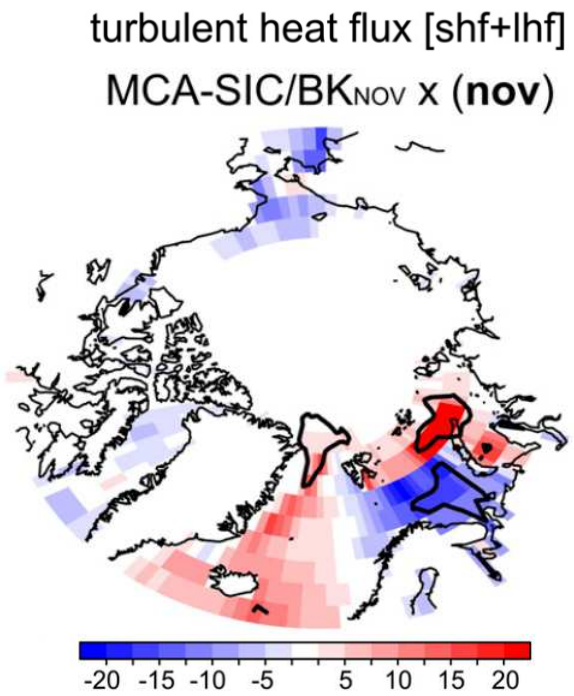


[Gastineau et al. 2017]

NAO precursors linked to surface forcing ?

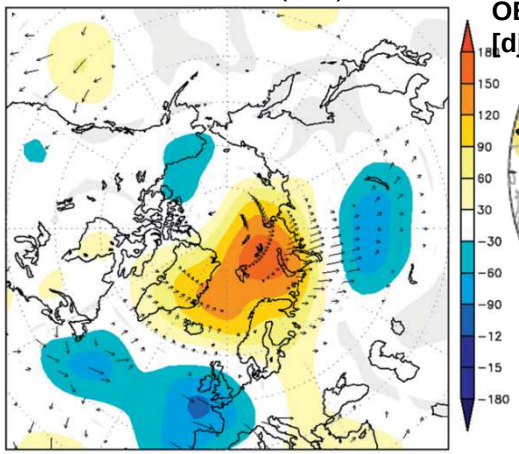
sea-ice reduction → heats and moistens the boundary layer (*turbulent fluxes*)

increased snow → cools the boundary layer (*radiative fluxes*)

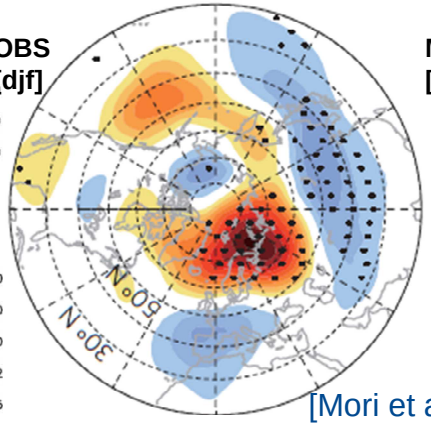


[García-Serrano et al. 2015]

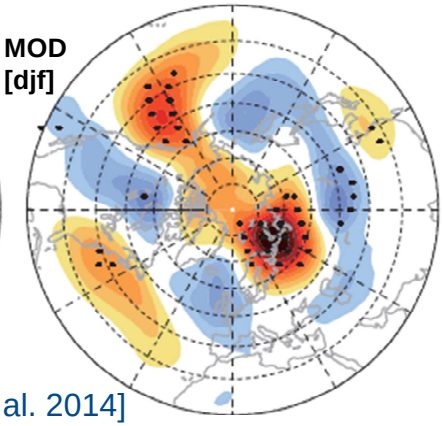
Z250 / WAF (DJF)



OBS [djf]

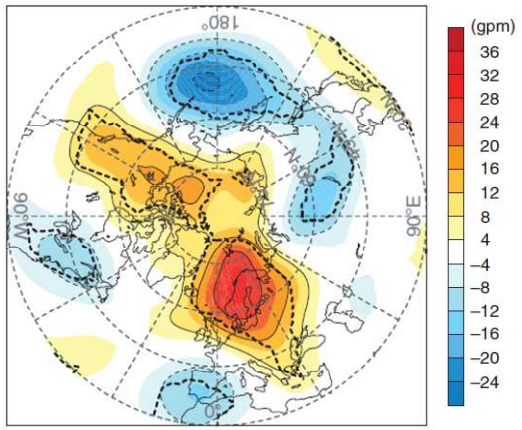


MOD [djf]



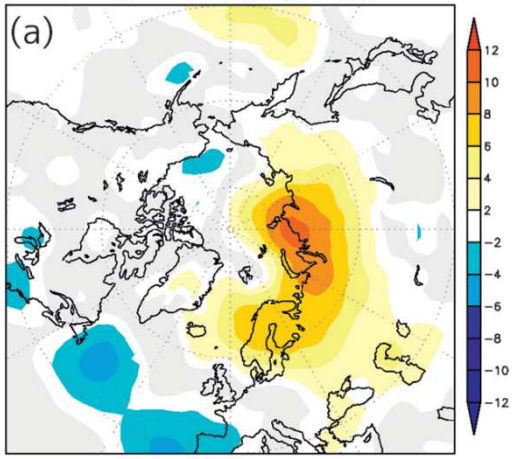
[Mori et al. 2014]

ΔZ500 for ND, CAM5

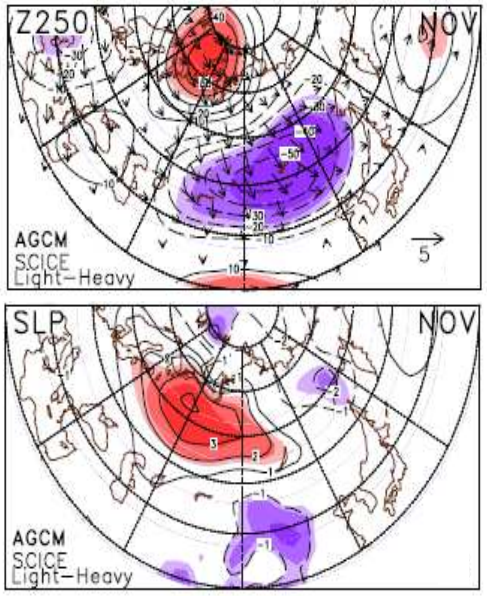


[Kim et al. 2014]

SLP$_{key}$ anomaly (Ice$_{light}$–Ice$_{heavy}$)

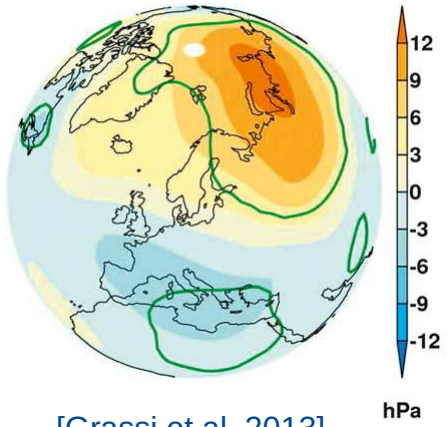


[Inoue et al. 2012]



[Honda et al. 2009]

SLP JAN [CAM]



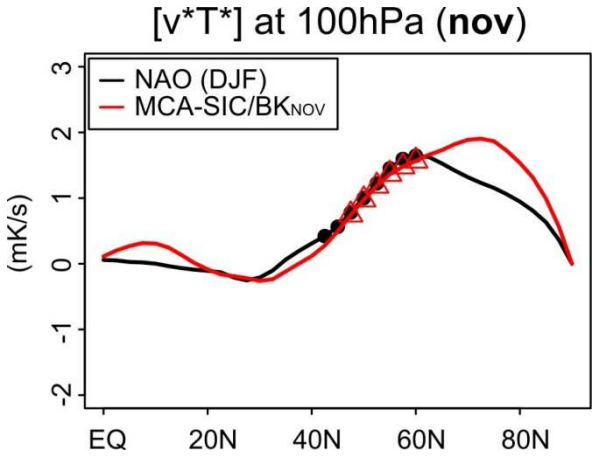
[Grassi et al. 2013]

might be non-linear to SIC reduction!

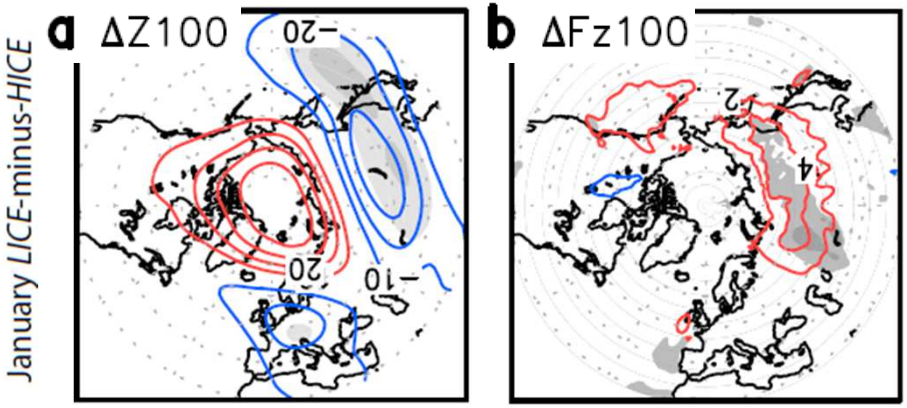
[Petoukhov and Semenov 2010]

MEDSCOPE
MeDiterranean Services Chain based On climate PrEdictions

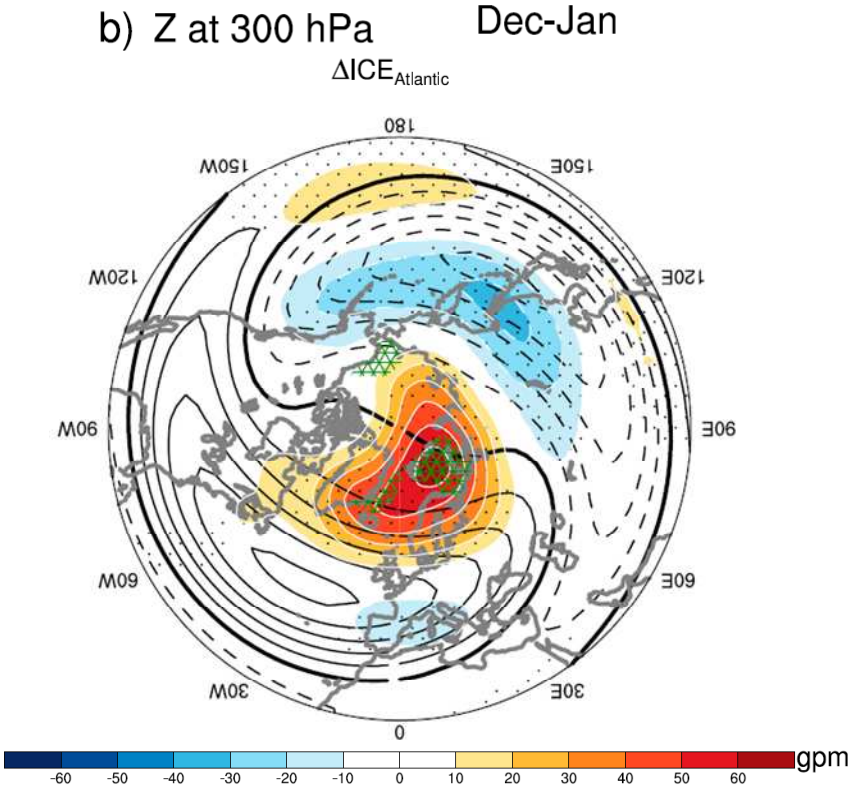
RECENT REVIEWS: Cohen et al. 2014; Vihma 2014; Walsh 2014; Gao et al. 2015; Overland et al. 2015; Screen et al. 2018



[García-Serrano et al. 2015]



[Nakamura et al. 2016]



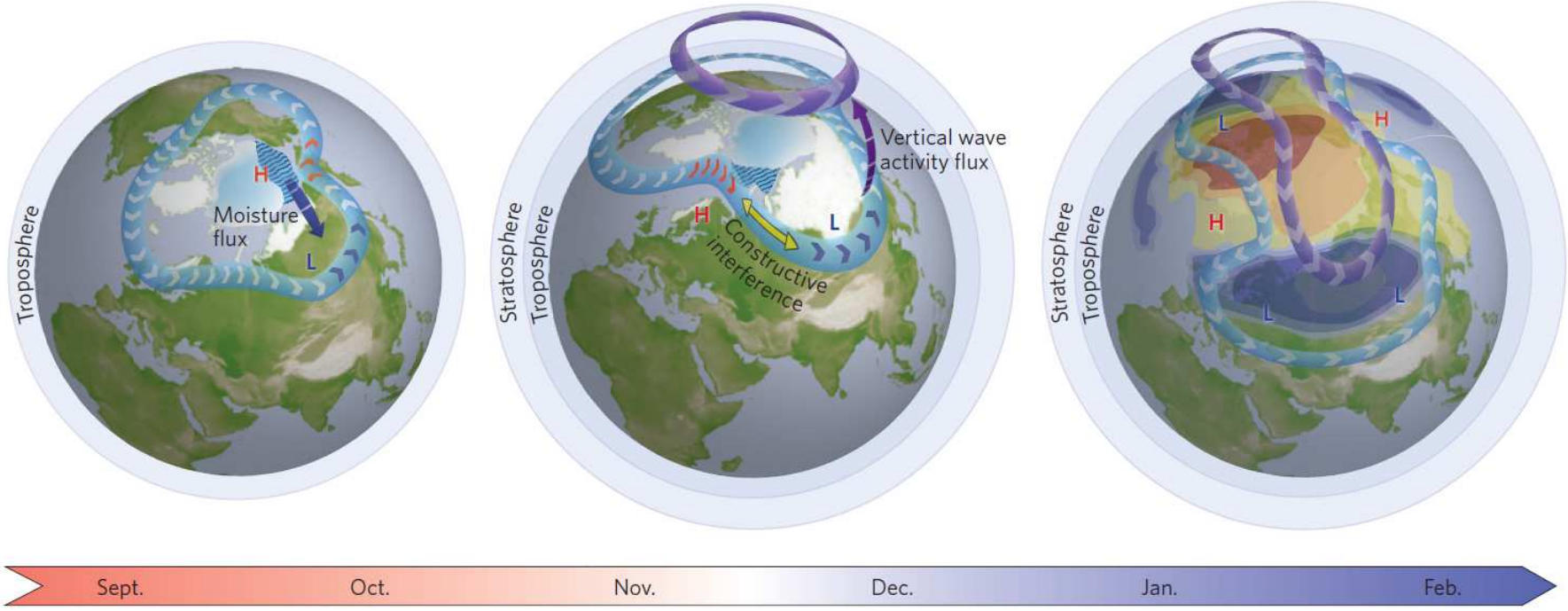
[Sun et al. 2015]

might be non-linear to SIC reduction!

[Petoukhov and Semenov 2010]

RECENT REVIEWS: Cohen et al. 2014; Vihma 2014; Walsh 2014; Gao et al. 2015; Overland et al. 2015; Screen et al. 2018

predictability of Northern Hemisphere climate from cryospheric variability (sea-ice + snow cover)



Review in *Nature Geoscience*
[Cohen et al. 2014]

Universitat de Barcelona

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

SUMMARY:

- …other forcings may play a larger role in seasons when ENSO signal is weak

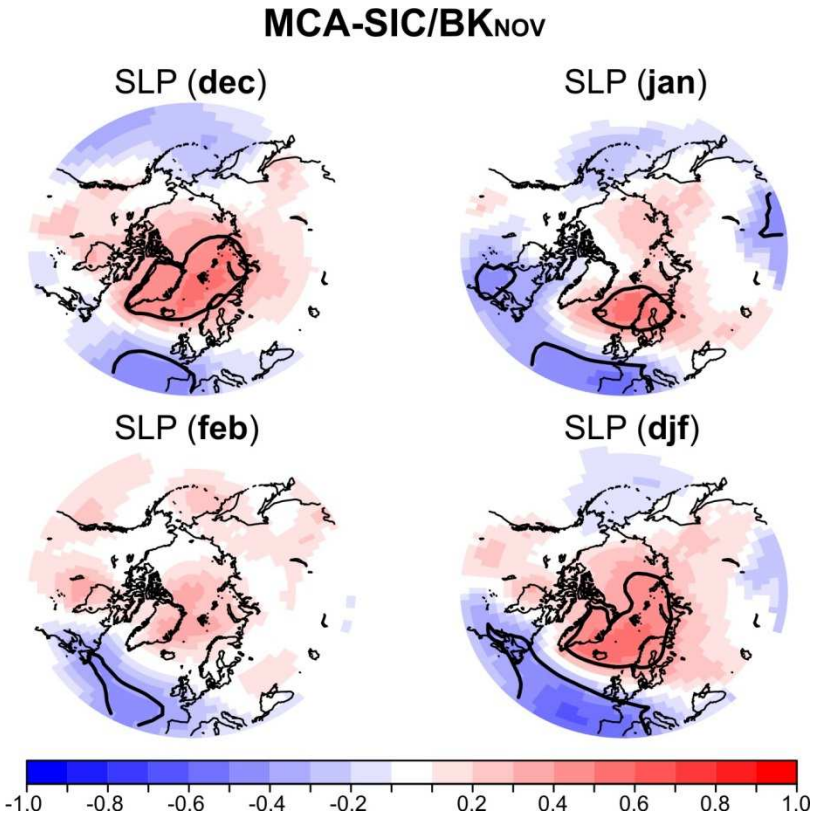
- SEA-ICE (*Barents-Kara Seas*): thermally-induced / turbulent heat flux (sensible+latent) – Rossby wavetrain – interference with climatological wave pattern

- SNOW COVER (*Eurasia*): radiatively-induced / albedo feedback – local baroclinic structure – interference with climatological wave pattern

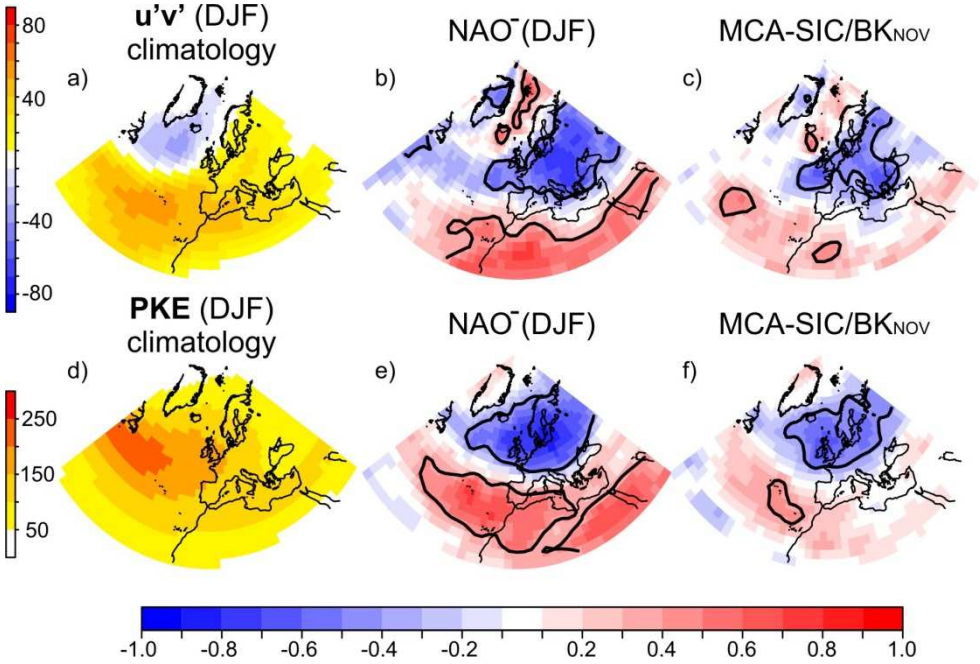
→ dynamical forecast systems will require a proper representation of stratosphere

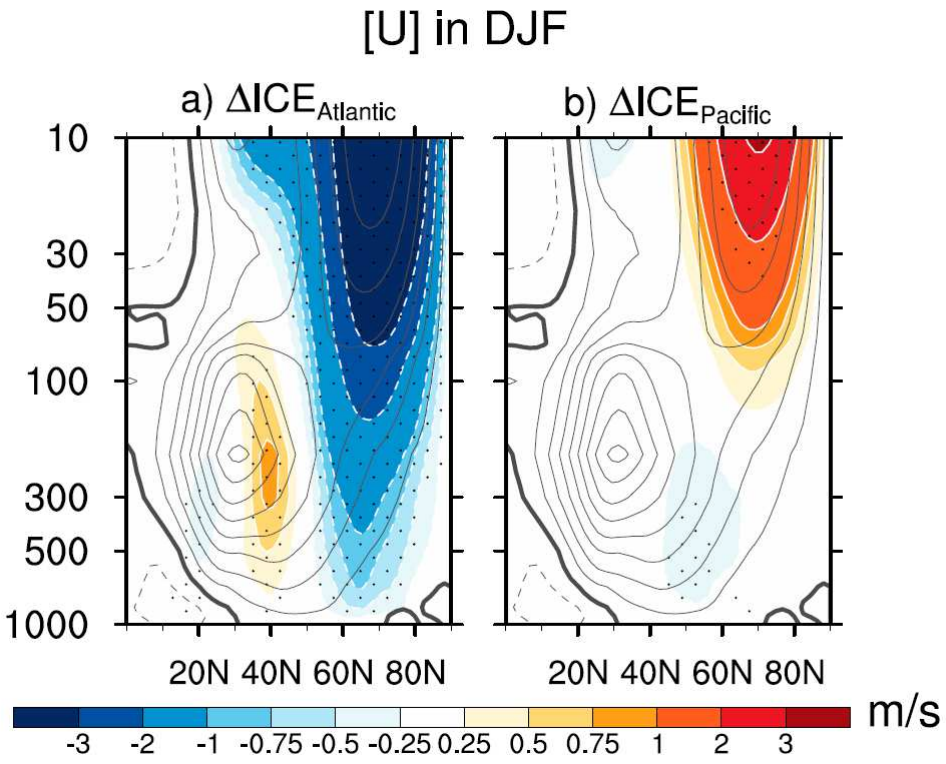
→ there is room for comprehensively improving empirical prediction models

MEDSCOPE
MEDiterranean Services Chain based On climate PrEdictions

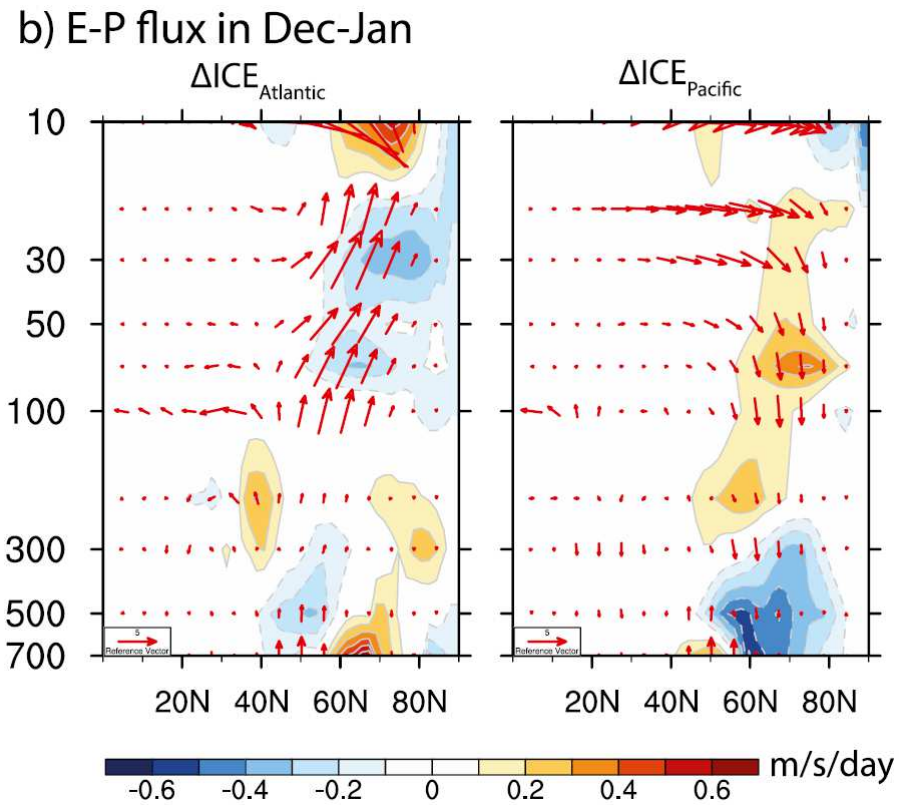


[García-Serrano et al. 2015]

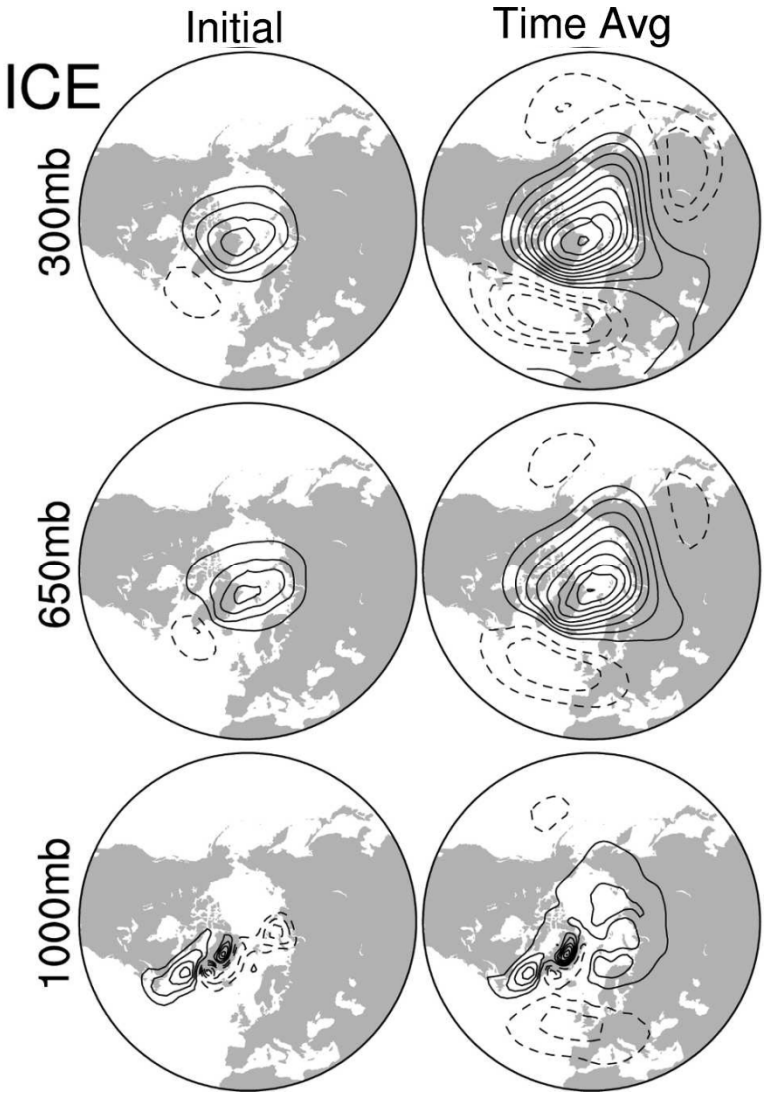


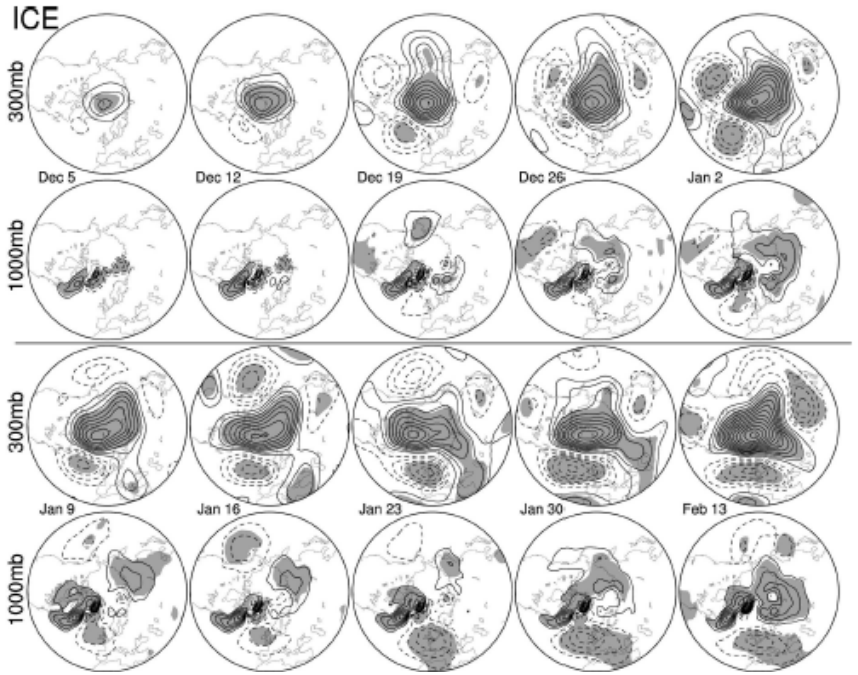


[Sun et al. 2015]



MEDSCOPE
MeDiterranean Services Chain based On climate PrEdictions

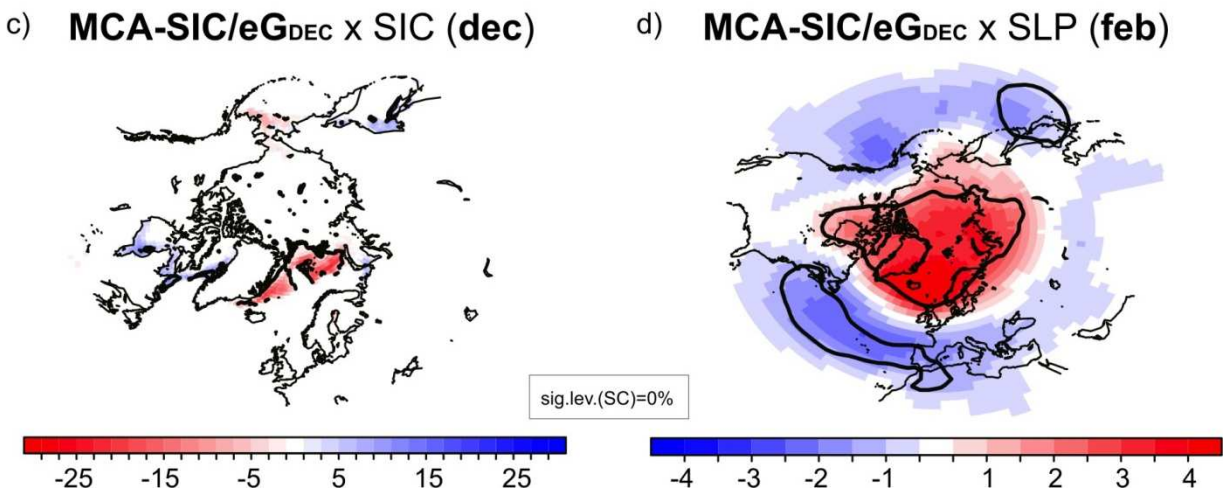




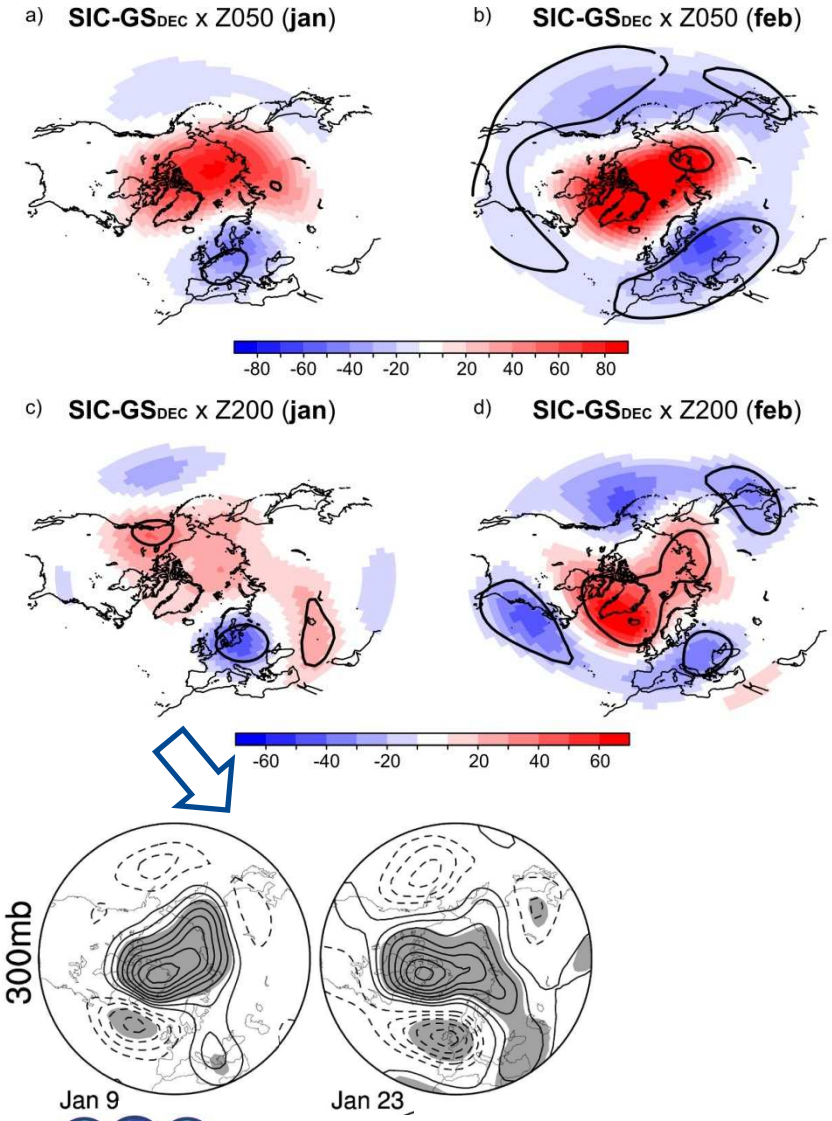
the equilibrium response to SIC reduction over G-B Seas, which projects on the negative NAO, is reached in about two months

[Deser et al. 2007]

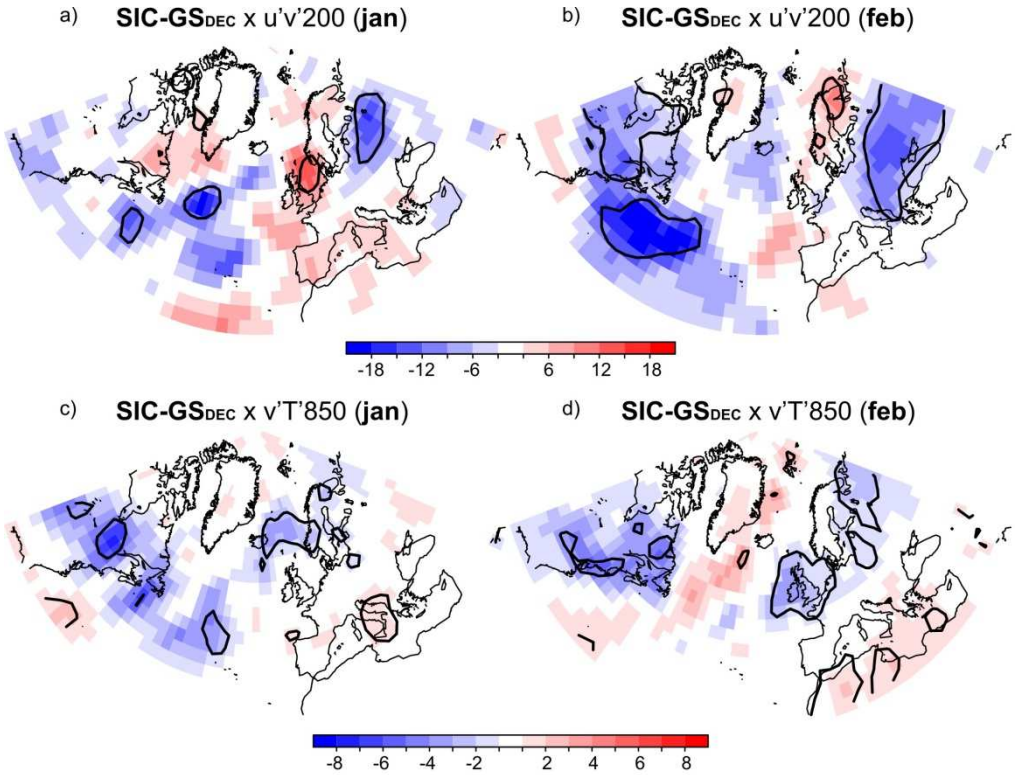
MEDSCOPE
MeDiterranean Services Chain based On climate PrEdictions



[García-Serrano et al. 2016]



[Deser et al. 2007]



[García-Serrano and Frankignoul 2015]

TROPOSPHERIC DYNAMICS